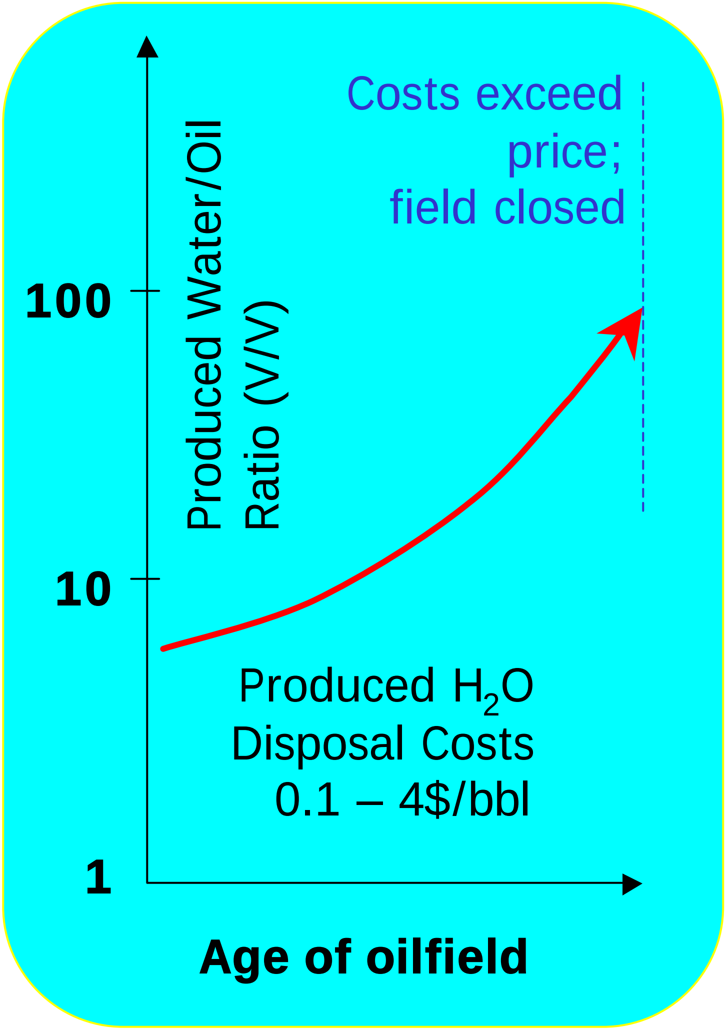
Bioreactor for Reclamation of Oilfield Produced Waters

Nadim R. Khandaker, Allan R Sattler, Dave Borns, Sandia National Laboratories
Robert Lee, Petroleum Recovery Center, New Mexico Tech
James C. Young, University of Arkansas, Fayetteville

present



produced H_2O

- 10^{12} gallons per year (U.S.) (~10^{6} acre-feet)

proposal

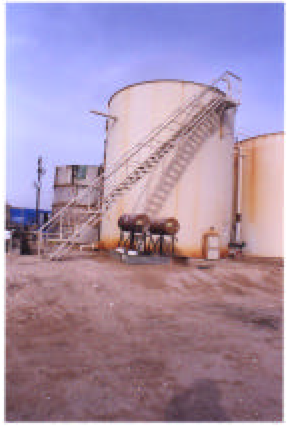
Use advanced biochemical processing to reclaim oilfield brine, converting environmental liability into a marketable resource:

- Extends oilfield life
- Lowers oilfield costs
- Offsets use of dwindling groundwater source

Background

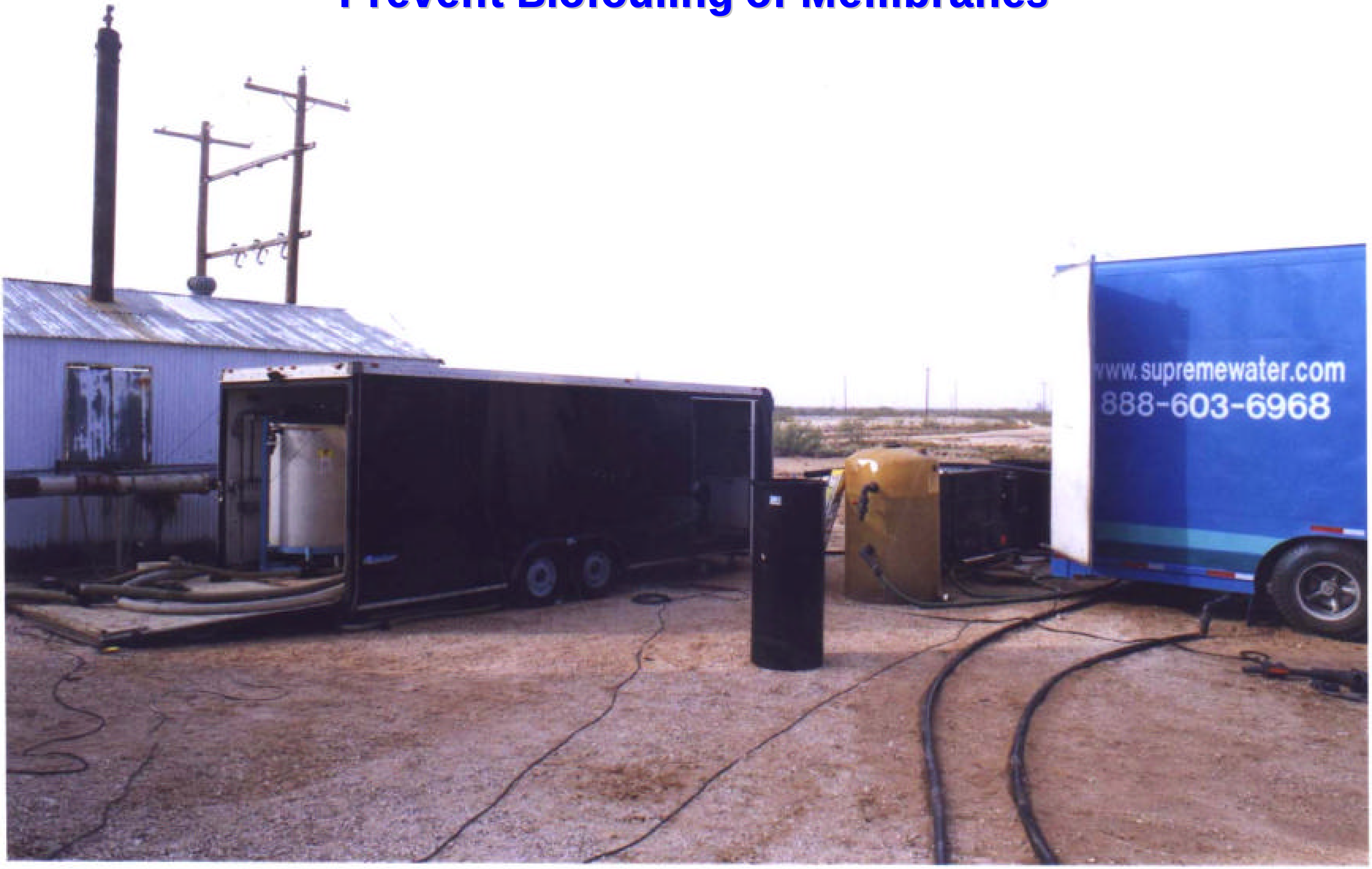
- For every barrel of oil produced, 6 barrels of brine produced
- ~3 million acre ft/yr disposed, ~ 1/6 of our drinking water
- Much of the water being thrown away in regions where it is needed badly
- Reclaimed water, relieve draw down on, replenish depleting groundwater
- *PRODUCED WATER, one of the producers **<u>most critical problems</u>***

Separator Treated Oilfield Brine Tanks



Various Feed Tanks in Front of Brine Processing & RO Trailer

Pretreatment Stage(s) Necessary Between the Feed (Oilfield Produced) Brine and Actual Reverse Osmosis Process to Prevent Biofouling of Membranes



Unique Economics of Pre Treating and Desalinating Oilfield Brine

- In Lea County, New Mexico, oil and gas producers pay ~35 cents/Bbl to dispose of 1,000,000 Bbl/day of oilfield brine
- Ironically, producers pay nearly same rate to draw 10,000 Bbl/day of fresh groundwater
- Potash mining draws another 60,000 Bbl/day from the Ogallala aquifer
- The fee for disposing all the oilfield brine need not be paid if the brine can be used beneficially
- If the treated brine is used beneficially, it will have intrinsic, saleable value

INDUSTRY, INSTITUTIONAL CONTACTS AND PARTNERS

SUPPLY SIDE

EPA

Shell

Regional Industrial Wastewater Plant, Houston

Exxon Mobile

Plant in Wyoming Treating Condensates

PRODUCER SIDE

Independent Petroleum Association of New Mexico (IPANM)

New Mexico Oil and Gas Association (NMOGA)

Lea County, New Mexico, Soil and Water Conservation District

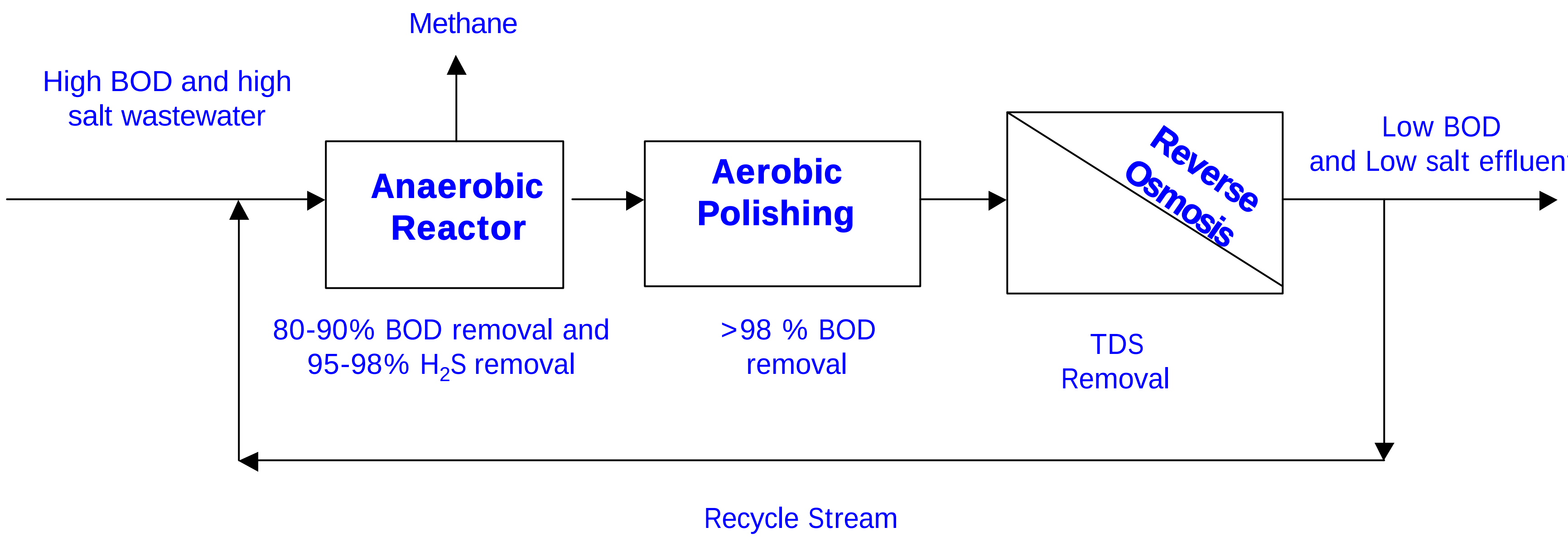
Amerada Hess, Phillips Petroleum Co., Chevron Texaco, Controlled Recovery Inc., Harvard Petroleum Corporation, Strata Production Company, Cactus Operating Co., LLC, Lasco Construction Co., Read and Stevens Inc., Cactus Tank Rental, Merrian Oil and Gas, Others

Objective: To develop effective pretreatment in conjunction with reverse osmosis process to reclaim produced water for beneficial use.

- Pretreat to remove organics and solids that can potentially degrade or foul reverse osmosis membranes.
- Optimize design and operation of pretreatment and reverse osmosis system.

Efficient ,cost effective , and environmentally friendly process for treating oil field produced waters

Proposed Treatment Process



Research Plan

Task I **To address fundamental biological treatability and membrane selection and optimal operation:**

- **Bench-scale biological treatability study with ranges of oilfield produced waters and bench scale control reverse osmosis (R.O.) run with untreated oilfield produced waters.**

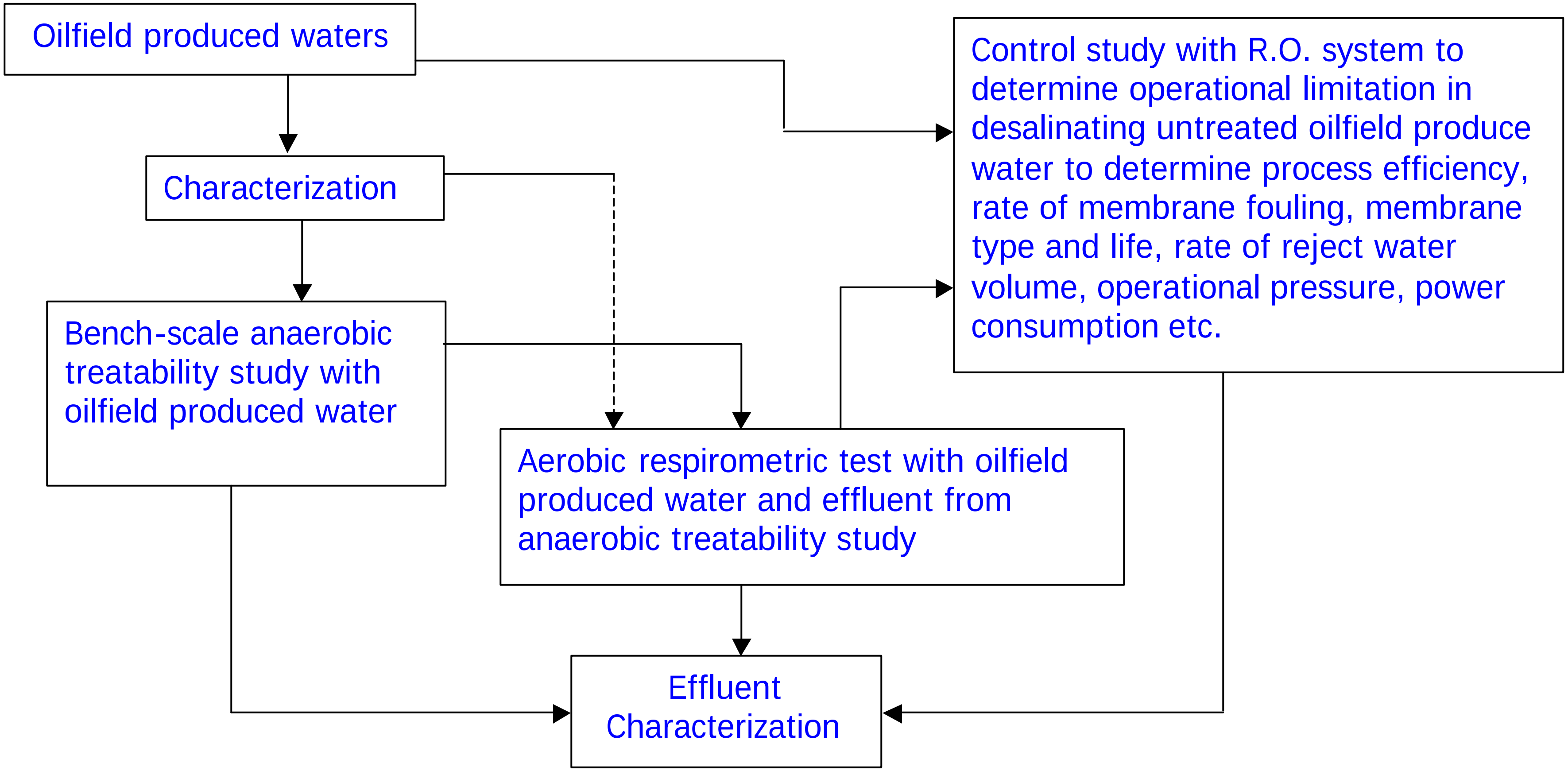
Task II **For process selection—development of treatment train and process optimization:**

- **Laboratory scale pilot study with successful candidate oilfield produced waters from Task I.**

Task III **To address process scale-up issues:**

- **Field scale pilot study with the more successful candidate oilfield produced water using the most optimum treatment process.**

Task I: Bench-Scale Testing



Water characterization: COD, BOD_u, TSS, VSS, ICP scan, GC-MS scan

Task I- Anaerobic and Aerobic Treatability Study

(Based on established protocol)

•The anaerobic and aerobic treatability study (*Khandaker, 1990; Khandaker and Young, 1991; Khandaker and Young, 1992; Khandaker and Young, 1994; Khandaker 1995*) address such fundamental properties as:

- •Culture acclimation, Rate and extent of degradation
- •Effects of dilution, toxicity, operation pH, HRT, SRT

•Central to the treatability studies--the operation of ***10-L master culture reactors*** (MCRs), operated at fixed HRT and SRT to serve as a source of culture with constant composition for subsequent bench scale studies.

•The ***bench-scale reactors*** (BSRs) will range in size from 250 ml to 500 ml containing cultures transferred from the master culture reactor.

•***Respirometers***-- to monitor real time reactor performances by measuring methane generation for anaerobic systems and oxygen consumption for aerobic systems. Both the MCRs and the BSRs will be operated in a ***semi-batch*** mode.

Task I- R.O. Control Run

•In parallel with the biological pretreatment ***control R.O. runs*** will be carried out using different untreated oilfield produced water.

•The purpose of these runs will be to have ***baseline data for comparison with pretreated oilfield produced water*** in terms of efficiency of operation of the R.O. systems.

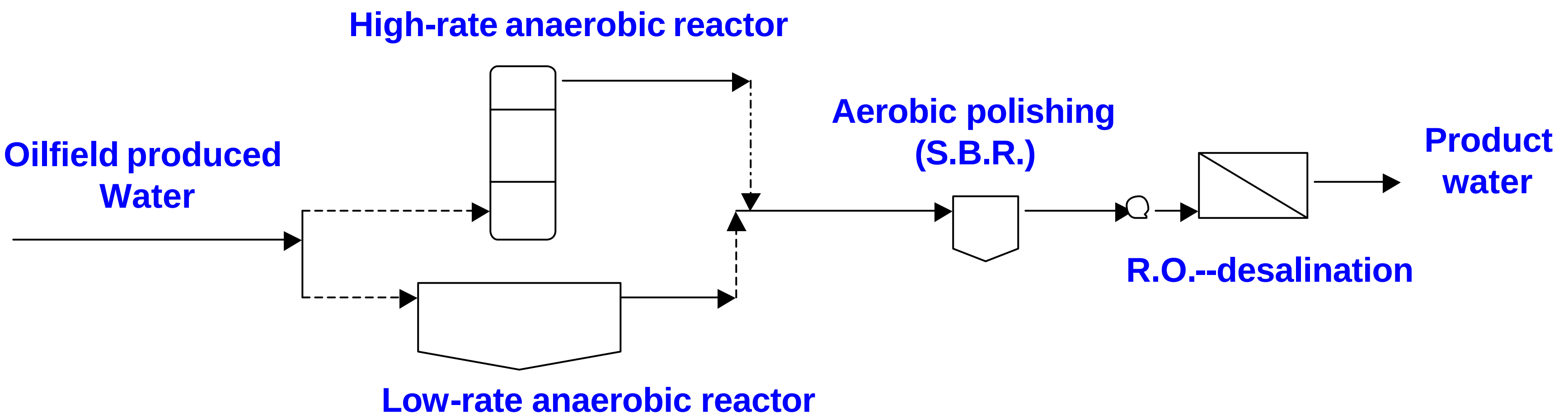
•The parameters of concern are: ***membrane type***, percent reject water, salt rejection rate, water flux, time between flushing, membrane life etc.

•Depending on the characteristics of the oilfield produced water; the flux used for the R.O. system will ***range from 0.015 to 0.3 (or recommendation of manufacturer) gpm/sqft***.

•The bench-scale R.O. systems will be sized to handle a max flow of 2.5 liters a minute, which corresponds to a membrane surface, are of ***1.0 sqft***.

Task II-Lab Scale Pilot Systems

•Task II: involves the operation of laboratory scale contentious flow laboratory pilot scale biological reactors connected in series to the reverse osmosis system.



- The objective of Task II is to operate pilot systems for optimum process selection and optimization for both pretreatment and R.O. steps for candidate oilfield produced waters from Task I.
  - Biological system optimization parameters: SRT, HRT, COD loading rate, pH, Temperature, etc.
  - Precipitation and removal of inorganic salts such as calcium carbonate, silicates, and sulfates if required.
  - R.O. system optimization parameters: operating pressure, flux, membrane type, etc.

Task III Field Scale Pilot Study

Oilfield produced water specific pretreatment process from Task I and II

R.O system with optimal performance membrane from Task I and II

Task III

Operation of field scale pilot field unit to address:

- process scale-up
- regulatory issues regarding discharge of treated water for agricultural or industrial use
- byproduct management: methane for beneficial use, purification of H2S in off gas, bio-solids management, reject water etc.
- Process economics

Comprehensive Process Selection and Design Guideline

For Treating Oilfield Produced Waters Using Biological-chemical Pretreatment combined with reverse osmosis

- **A treatment process which will be:**
- **Efficient**
- **Cost effective**
- **Produce a product water which can be put to beneficial use for industry and agriculture**
- **Environmentally friendly: Unlike existing process will only generate by products which are not hazardous and do not require specialized handling**

Project Timeline and Milestones

Deliverables	Quarter I	Quarter II	Quarter III	Quarter IV
TaskI (year 1)				
Project Initiation---Procurement and installation of equipment				
MCR –operation				
Biological Treatability Studies				
Control R.O. Runs				
Comprehensive report stage-I				
Task II (year 2)				
In-house construction of lab pilot units				
Operation and optimization of lab pilot units				
Comprehensive report stage-II				
Task III (year 3)				
Project site selection				
Procurement of equipment for field pilots				
Operation of field pilot systems				
Comprehensive report stage-III				
Overall project report				

Budget Summary

	FY 03		FY 04		FY 05	
	Task 1	Task 2	Task 2	Task 3	Task 2	Task3
Sandia	150	55	45	160	45	160
NM Tech	35	20	20	35	20	45
U Ark.	20	10	10	20	10	20
DOE Total	205	85	75	215	75	225
In Kind						
Labs,Univ	75	30	30	65	30	65
Industry	80	50	50	80	50	220